"Space means science, unless it's about Star Wars": A qualitative assessment of science communication audience segments

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“Space means Science, unless it's about Star Wars”: A Qualitative Assessment of Science Communication Audience Segments

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Keywords: Science Communication, Perceptions of Science, Audience, Segmentation Analysis, Qualitative Methods; Media Use

1. Introduction

Current changes in media environments have not left science communication untouched (Schäfer, 2017a). They have changed the proliferation of science-related content: The rise of the internet and social media has diversified the spectrum of voices and information in science communication, making more and more diverse content available.

The changing media environment also impacts the audiences of science communication. They can get in contact with science in many ways: via online news portals, Wikipedia, blogs, social networks, video platforms and elsewhere (Brossard, 2013; Fischhoff and Scheufele, 2013; Schäfer, 2017b). This allows them to seek exactly the kinds of information and channels that suit them. As a result, individuals’ patterns of information and media use have become more diverse (Metag, 2017), and audiences more heterogeneous.

Identifying these different audience segments in science communication has received more scholarly attention in recent years (for overviews see Füchslin, 2019; Hine et al., 2014; Metag and Schäfer, 2018). Studies have reconstructed audience segments based on their general attitudes towards science (e.g. Kawamoto et al., 2013a), on their attitudes towards specific science-related issues such as climate change (e.g. Detenber et al., 2016; Metag et al., 2017), or on their patterns of information and media use with regards to science (e.g. Guenther and Weingart, 2017; Metag et al., 2018). The majority of these studies are based on quantitative, representative surveys which allow for a robust identification of audience groups. But this also comes with the typical shortcomings of quantitative studies: In-depth information about audience segments and their perceptions of science, or a detailed reconstruction of their patterns of information use are difficult to realize via large-scale surveys.

Thus, it is necessary to complement these quantitative studies with qualitative research, which allows for more in-depth descriptions. Therefore, we conducted a qualitative analysis of audience segments. In doing so, we employ novel methods, using smartphone-based media use diaries in combination with qualitative interviews. Our aim is to provide deeper insights into individuals' subjective perspectives on science: how they perceive it, how they get into contact with it, what they expect from science communication, how they evaluate it and what the situational and social contexts of their science-related information use are.

2. Conceptual Framework

2.1 Science-Related Information and Media Use

When audience segments in science communication are considered, two aspects have been focused on (cf. Metag and Schäfer, 2018): attitudes towards science and science-related information and media use. In past decades, a considerable number of concepts focusing on such perceptions and attitudes have been developed and translated into measurements for large-scale surveys (for an overview see Besley, 2013). For example, the three-dimensional model of attitudes by Ajzen (1989), which differentiates cognitive, affective and conative attitudes, was used repeatedly (e.g. Schäfer 2018). The cognitive dimensions refer to constructs such as scientific literacy or interest (Kawamoto et al., 2013a, 2013b; Miller, 1983) while the affective aspect encompasses emotions towards an attitude object (Ajzen, 1989), i.e. science in this case. The conative aspect refers to behavioral intentions or actual behavior (Ajzen, 1989) such as people's search for information about scientific issues (cf. Bauer, 2016; Eurobarometer, 2005). Additionally, science communication scholars have identified people's reservations and beliefs with regards to science (Bauer, 2016) as well as norms and preferences regarding the relationship between science and society (Mejlgaard and Stares, 2010) as relevant dimensions of attitudes towards science (Schäfer et al., 2018).

Beyond that, scholars have focused on individual patterns of information and media use. First, they have focused on journalistic media and demonstrated that these were important sources of science-related information for many (e.g. Nisbet et al., 2002). Second, scholars have turned towards online sources and social media due to their considerably increased importance in relation to (and beyond) scientific issues (Brossard, 2013; Brossard and Scheufele, 2013; Schäfer, 2017a). They have analyzed the use of search engines and websites, social networking sites, (micro-)blogs, video portals and other social media, showing that the internet has become the most important channel for science-related content in the US (NSF, 2018) and increasingly important in other countries as well (e.g. Eurobarometer, 2005; Schäfer et al., 2018; Wissenschaft Im Dialog, 2015). Third, scholars have taken non-mediated sources into account. They have shown that many people inform themselves about science-related topics in museums and science centers, zoos, at talks or other science-related events (e.g. BBVA foundation, 2011; OST and Wellcome Trust, 2001). Moreover, scholars have also assessed why people turn to these channels (e.g. Kahlor and Rosenthal, 2009), how they perceive and evaluate them (e.g. Eveland, 2001; Eveland Jr et al., 2009), and the impact they have (for an overview see Metag, 2017).

2.2 Segmentation Analyses

In light of the new opportunities for individuals to compose their own media and information repertoires, audience segmentation analyses have gained prominence in science communication (see Füchslin, 2019; Hine et al., 2014; Metag and Schäfer, 2018 for overviews). Generally, they aim to analytically "divide the general public into relatively homogeneous, mutually exclusive subgroupings" (Hine et al., 2014: 442). For a given population, they collect data on characteristics that are deemed analytically interesting, and reconstruct segments of the population, which are internally homogeneous in these characteristics while differing from other segments externally.

Almost all of these studies are based on standardized surveys (e.g. Füchslin, 2019; Metag and Schäfer, 2018), and most of them segment the public according to their attitudes on a given topic. Such analyses exist for general attitudes towards science, most describing a spectrum of population segments ranging from strong support towards science to skepticism or criticism (e.g. Guenther and Weingart, 2017; Kawamoto et al., 2013a; OST, 2005; Schäfer et al., 2018). Segmentation analyses have also been done for specific fields of science, e.g. for attitudes towards medicine (see the meta-analysis of Noar et al., 2007) or biomedical science (Nisbet and Markowitz, 2014). They are particularly common in analyses of attitudes towards global warming (for an overview see Hine et al., 2014; Leiserowitz et al., 2013; Metag et al., 2017).

These studies are instructive for us because they show different levels of support for science or specific science-related issues as well as their psycho- and sociodemographic basis in a given population. Moreover, they identify potential audience fragmentations for science communication. For that, it is necessary to include peoples' patterns of information and media use in segmentation analyses, and several authors have done that. They have shown that different segments differ in their media diets, both with regards to science in general (e.g. Metag et al., 2017; OST, 2005) and to specific issues like climate change (Leiserowitz et al., 2010; Metag et al., 2017) or environmental protection (Hefner, 2013).

2.3 Balancing Quantitative Survey Studies with Qualitative Methods

These segmentation analyses are almost exclusively based on large-scale, representative, quantitative survey data, which allows robust identification of segments (Hine et al., 2014: 452). But the standardized nature of these studies, naturally, limits them to more generic analyses. On the one hand, a deeper understanding of the amount and kinds of science people encounter in their daily lives, of the content and phenomena they consider to be scientific, and of their subjective criteria to make these decisions is difficult to obtain in detail.

On the other hand, the few segmentation studies including media variables mostly account for how often people use certain sources, or how they evaluate them and their content (for an overview see Metag and Schäfer, 2018). More detailed assessments of individuals' criteria for 'good' science communication, the topics they encounter, whether they search for science-related content actively, and whether they delve into it deeply or only superficially has not been – and can hardly be – done in quantitative studies. Additionally, the social embedding of individuals' media use and the follow-up communication is usually not considered.

But such detailed, in-depth descriptions are a strength of qualitative methodology. It allows for „thick descriptions“ (Geertz, 2008) proximate to the specific characteristics of the cases under analysis. Therefore, we will complement a quantitative segmentation analysis with a qualitative study.

Such a qualitative analyses can draw on prior research, namely on the (very few) segmentation studies that have included qualitative parts (MORI, 2014; OST, 2005; OST and Wellcome Trust, 2001) and on research using qualitative methods to reconstruct people's perceptions and subjective images of science (Guenther et al., 2018; Miller, 2003; Putsche et al., 2017). These studies reveal, for example, that people have different perceptions of what science is and how they make sense of it. They demonstrate that individuals mostly associate science with natural sciences (e.g. biology, physics, chemistry), health or medicine (MORI, 2014). In their everyday life, they encounter science in various way, from using technology such as cars or computers over school to discoveries in nature (MORI, 2014). However, people are often not aware of science in their everyday life and revert to examples from school when asked to describe science (OST and Wellcome Trust, 2001).

2.4 Audience Segments under the Magnifying Glass: Our Study

Since both quantitative and qualitative studies have their advantages and limitations, combining both methods is ideal. This has rarely been done in research on science communication. The few exceptions are older studies from the UK's Office of Science and Technology (OST, 2005; OST and Wellcome Trust, 2001) which identify audience segments based on quantitative surveys as well as qualitative focus-groups – but more recent studies are lacking. This is particularly surprising since digital and mobile technologies provide more options to do qualitative research (e.g. Paulus et al., 2013).

We address this gap by using a mixed methods approach combining the rigor of quantitative segment identification with in-depth, qualitative description. Our analysis is based on a quantitative segmentation analysis using the "Science Barometer Switzerland" survey (Schäfer et al., 2018) which assesses the Swiss' attitudes towards science and their science-related patterns of information and media use. Conducted in 2016, it surveyed 1,051 respondents from all regions of the country. Schäfer et al. used 20 attitudinal variables[1] from the survey in Latent Class Analysis to identify four segments of the Swiss population:

1. The *„Sciencephiles"* (n=292; 27.8%, mostly consisting of highly educated men) have a high interest in, extensive knowledge of, and very positive attitudes towards science. *Sciencephiles* think that science is important in their lives and are highly supportive of it. They actively search for science-related information in a broad set of sources, use those extensively, and discuss science-related content with others.
2. The *"Critically Interested"* (n=181; 17.2%, mostly highly educated respondents and politically more liberal), mirror the *"Sciencephiles"* in their extensive knowledge of and positive attitudes towards science. They differ with regards to trust in science, of which they have less, and by having stronger reservations regarding science's promises. They also favor restraints on some research. Like the "*Sciencephiles*", they use many sources extensively and actively, but trust science journalism in legacy media less.
3. The *"Passive Supporters"* (n=437, 41.5%, representing the mainstream of the Swiss population in many sociodemographic variables) are the third and largest group. Regarding their interest in and attitudes towards science, they are moderate. They are supportive of science, albeit less strong than the previous two groups, but also have

[1] Füchslin et al. (2018) proposed a shorter 10-item version to achieve the same goal with still high accuracy.

some reservations and think that scientific research should have clear constraints. They encounter science-related content not by actively searching for it, but as part of their routine use of news media, mostly via newspapers and TV.

4. The *"Disengaged"* (n=141; 13.4%, mostly consisting of lower educated women) represent the smallest segment. They have the least pronounced interest in and least positive attitudes towards science. They do not think that science is important in their lives, and know least about it. This is correlated to a marginal use of science-related information and media: They have the "fewest contacts with science across almost all mass media and online sources. The only sources they use as often as others regarding science are public TV—the '*Disengaged*'s' main source—public radio, and Facebook." (Schäfer et al., 2018: 850)

Our aim is to detail these quantitative findings qualitatively. We focus on two research dimensions, which are similar to the quantitative study but adapted to this in-depth analysis:

RQ1: What subjective perceptions of science can be found?

RQ2: What are the qualitative patterns of science-related information and media use?

3. Data and Methods

3.1 Sampling

At the end of the «Science Barometer Switzerland» 191 *Sciencephiles*, 116 *Critically Interested*, 256 *Passive Supporters* and 59 *Disengaged* agreed to be contacted for a follow up study and provided their contact details.[2] We selected representatives of each segment, systematically varying age, gender and regional origin, aiming at including ten participants per segment. This goal was met for three segments. For the *Disengaged* segment, we could not find 10 participants despite extensive efforts. The final sample consisted of 41 participants as we recruited more participants from other segments after realizing we would not achieve 10 *Disengaged* participants (see Table 1).

[2] The institute conducting the quantitative survey contractually committed itself to adhering to the ethical standards of its professional association. All participants were informed in detail about the analysis, participants' consent was actively obtained. The research team signed a declaration to respect participants' anonymity and not to pass on any personal information. Respondents voluntarily participated and decided themselves which information and data to post in the diaries and which information to give to the research team. No metadata was collected.

	Sciencephiles	Critically Interested	Passive Supporters	Disengaged
German speaking part of Switzerland	7	7	8	5
French speaking part of Switzerland	4	4	6	0
Female	3	6	8	2
Male	8	5	6	3
34 years or younger	4	4	7	2
35 - 54 years	3	2	5	2
55 years or older	4	5	2	1
Total	**11**	**11**	**14**	**5**

Table 1: Overview over Core Sample Characteristics.

3.2 Data Acquisition: Smartphone-Based Diaries and Semi-Structured Interviews

Data collection took place in two steps, inspired by Carter and Mankoff (2005) who combined a photo diary study with subsequent qualitative interviews. Accordingly, we asked participants to fill in smartphone-based media diaries (for descriptions see Berg and Düvel, 2012). Diaries have rarely been used in science communication research, but disciplines such as psychology and health research demonstrate their usefulness for research purposes. In communication sciences, Kuhlmann and Wolling (2004), Peters (2003) and Naab (2013) showed the potential. Their advantage is that they collect data about participants' behavior in real time and in natural environments (Kuntsche and Labhart, 2013; Shiffman et al., 2008), recognizing "the importance of the contexts in which [social] processes unfold" (Bolger et al., 2003: 580). Additionally, because data can be collected immediately and/or close to relevant event, the risk of memory loss or retrospective distortion is reduced (cf. Bolger et al., 2003: 580; Iida et al., 2012: 278). A potential disadvantage of the method is that it could intervene in daily routines and may sensitize participants to the subject under study (Schlütz and Scherer, 2001: 147; Shiffman et al. 2008: 20). We considered this bias acceptable as we are interested in comparing different segments which would all be prone to such bias equally. Another disadvantage – that media diaries may be awkward to handle and tedious to fill in – can be remedied considerably by using electronic, smartphone-based diaries (Kuntsche and Labhart, 2013).

We used the commercial “Evernote” software, intended primarily as a notetaking tool and providing an app and web application, for the diaries. Evernote’s functionality was tested in two prior studies (Koch et al., 2014). Research staff met with all participants, installing the software on their smartphones and giving instructions. Then, for a two-week period from March 5 to 18, 2018, participants were asked to record all their encounters with science. This task was deliberately formulated openly. No definition of science was given; instead, participants were encouraged to collect whatever they considered as science. In order to exemplify different kinds of potential encounters, examples of possible channels were given, such as advertisements, news media, museums and personal conversations.In the diaries, encounters could be written down, photographed, print-screened or video/audio recorded. Additionally, respondents could add comments and select tags from a list of default tags evaluating the information, describing the setting in which it was found and how they used it. During field time, diary entries were synchronized permanently, enabling us to track data collection in real time. Within ten days after the diary phase, all participants were interviewed individually about their entries, experiences and reflections. During these qualitative, semi-structured interviews, which lasted about one hour, as many entries as possible were discussed, focusing both on typical entries as well as trying to ensure diversity in terms of scientific topics and disciplines, text types and sources.

The interviews asked where participants had encountered science, according to which criteria they decided that something was indeed science, how they found, used and evaluated the respective content and its source, and whether it triggered follow-up communication. The succession of these questions varied, as interviewers were instructed to use the interview guideline flexibly while making sure to cover all questions. Afterwards, all interviews were transcribed verbatim.

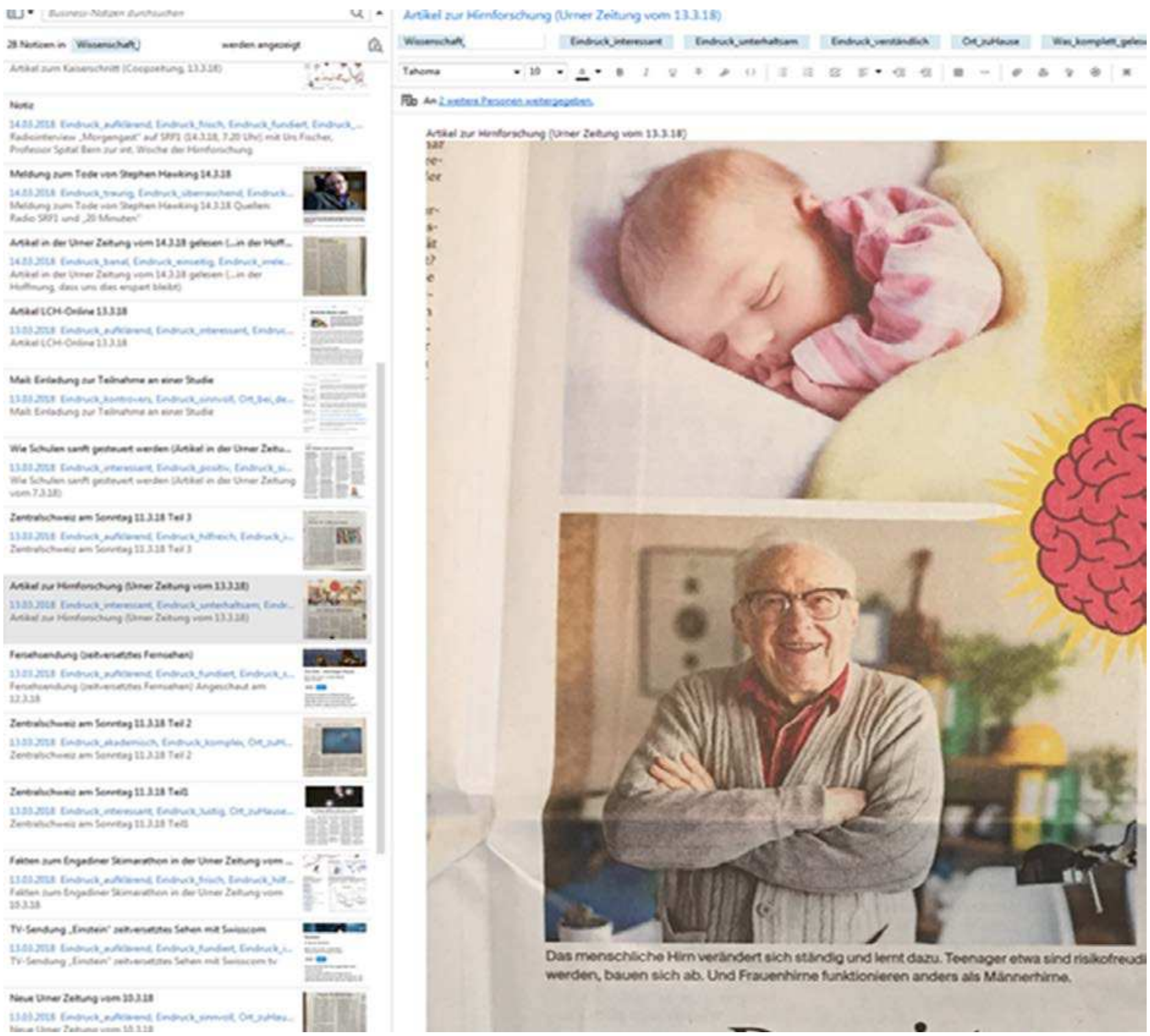

Figure 1: Anonymized example of a participant diary. The left column shows all entries with source name, date, selected keywords and picture. The content of one (highlighted) entry is displayed in detail on the right side. On the top right-hand side, the selected tags are displayed, containing information about where the content was found, how it was used and evaluated.

3.3 Data Analysis

Our data consisted of 41 diaries with 645 entries and 41 interviews transcripts. Analysis focused on participants' subjective perceptions of science and their use of information and media sources for scientific issues, along RQ1 and RQ2.

The data were analyzed using qualitative content analysis (Mayring, 2015), i.e. summarizing and paraphrasing interview statements along with diary entries into topical categories, which were repeatedly crosschecked with the original texts in an iterative process. On this basis, individual profiles were created for each participant along the analytical dimensions, describing them with paraphrased interview content and verbatim core statements as well as diary entries. Subsequently, all profiles from the same segment were compared, and generalizations iteratively crosschecked with the individual profile descriptions and, sometimes, the original interviews and diary entries. Afterwards, the aggregated results for each segment were compared with each other, again with crosschecks with segment and individual profiles. Additionally, to ensure that found differences or similarities between segments were accurately described, the main results were compared once more to the individual profiles and diary entries. Each step of the analysis was carried out by two or three researchers and the interpretive results were repeatedly discussed in the entire research team.

4. Results

4.1 Respondents' Perception of Science (RQ1)

The first aim of our study is the qualitative reconstruction of respondents' subjective perceptions of science. For that, we firstly assessed the *extent to which respondents' from different segments come into contact with what they consider to be science*, using the number of diary entries (see table 2 for an overview of the main results). Overall, diary entries suggest that, on average, participants report contacts with science on a daily basis. But this average masks differences between the segments: *Sciencephiles* report most science in their lives, with around 1.6 entries per day, followed by *Critically Interested* and *Passive Supporters* with an average of about one entry per day. The *Disengaged* report the fewest encounters with science, with 0.7 entries per day. When confronted with their own overall numbers in the interviews, the majority of respondents was surprised. They had expected more encounters with science: «[y]ou're confronted with science a lot. I also looked at the NZZ [Switzerland's main broadsheet] to see if it had any scientific articles and was amazed at how few it had».

Secondly, we analyzed *what objects* – such as disciplines, organizations, individuals, technical or natural phenomena etc. – *participants consider to be science*. The *Sciencephiles* and *Critically Interested* associate science mainly with STEM (science, technology, engineering, mathematics) and medicine. Their understanding of science conforms closely to the traditional understanding of science itself, but extends to objects developed by science. This was visible in their diary entries, which focused on topics like "astronomy", "robots", "animal research" or "'genetics". They also were exposed to social sciences and humanities, but much less so. Compared to the other two segments a clear disciplinary bias is apparent, which was not obvious for themselves. Only some participants revealed a critical opinion towards social sciences and humanities: "The mathematical demonstration of a physical or chemical phenomenon is much more reliable than the interpretation of a sample that is not necessarily representative as can be done in social sciences". In contrast, *Passive Supporters* report a broader spectrum of disciplines in their diaries, such as articles about "egoism", "future nutrition", "NASA research", "animal films", "architecture" or about "coffee and health". As the *Disengaged* had fewer encounters with science, a disciplinary focus is difficult to identify. *Disengaged* and *Passive Supporters* are distanced from science. They primarily identify science via trigger words such as "research" or "study", which signify that something is 'scientific' to them. In the diaries of *Disengaged's* articles or broadcasts about "fears of birth", "diet" or "flu" can be found. Overall, their subjective understanding of science sometimes deviate from established understandings of science, for example diary entries of "voting results", "stock exchange" or "a French fries factory" or when science is used as a metaphor ("It's a science for me, why people go there"). However, also some *Sciencephiles* had unexpected diary entries, e.g. pictures of asphalt, waterworks or trains. They reasoned it with the fact that there is a scientific research behind the object.

Thirdly, we aimed to reconstruct the *subjective criteria participants use to decide whether an object is science or scientific*. Two kinds of criteria seem to play a role for most participants: substantial criteria assessing the scientific substance of phenomena, e.g. by asking if scientific methods were applied or whether new knowledge was produced, and formal criteria which mostly looked whether an object was labelled with (allegedly) scientific terms (such as "science", "scientist", "research", "study", "specialist", "invention" or "professor"). In the application of these criteria, we found differences between segments:

The *Sciencephiles* focus primarily on substantial criteria, i.e. on scientific methods and results when deciding if something is science, stating, e.g., "[m]ethod, result and presentation – that shows me whether it's scientific or not". Some participants even added more depth to these descriptions, arguing that aspects beyond scientific methods and results are important to consider, such as how the subject is introduced ("You can tell by reading it. How [the scientist] psychologically assembles a character from the information units like a mosaic"), scope of results ("If I have test results, graphically displayed and if I then see the variance of the results") or the ability to influence and predict future development ("[Artificial Intelligence) will certainly be scientifically invented, as it is interesting to know what will come in the future").

The *Critically Interested* use a broader set of criteria. On the one hand, they also assess whether scientific methods were applied (e.g. "Someone must have sat down and studied it to come to conclusions.") or whether new knowledge was produced (e.g. "I was learning something that someone had explored first"). On the other hand, albeit clearly less prominently, the *Critically Interested* sometimes decide based on formal criteria and trigger words when deciding whether something is science ("I've tied that to the word 'technology'"; “Conferences are always science”).

In contrast, the *Passive Supporters* rely only on formal criteria and trigger words labelling phenomena as science. Typical for this group are statements like “A commercial ran and the phrase ‘scientifically proven’ was mentioned and some clever words" or “they threw around words like calcium, sodium” – and therefore, participants considered something as science. Some interviewees in this segment even argue that complex topics must be scientific (“There's a lot of things that I don't understand, so I think it's science”). They only sporadically mention substantial criteria, and if they do, they are not very elaborate and used more intuitively: “If it comes with tubes and samples, it's science to me", said one participant, and another “[i]t is a form of construction, so it is technical, so it is science”.

The *Disengaged* were often uncertain about what science is, e.g. describing it as “something abstract”. Therefore, labelling is by far their most important criterion – they mostly decide based on trigger words whether something is science or not: "If it is stated that this is a study. Then you think it's scientific", or “For me, space means science, unless it's about Star Wars.” Additionally, several participants from this segment reported to make some such decisions “intuitively”.

	Sciencephiles (n=11)	Critically Interested (n=11)	Passive Supporters (n=14)	Disengaged (n=5)
Perceptions of Science				
No. of diary entries (mean / median / daily entries)	22.6 / 24 / 1.6	13.0 / 14 / 0.9	14.6 / 11.5 / 1.0	9.6 / 10 / 0.7
Phenomena perceived as science	mostly STEM & medicine	mostly STEM & medicine	no clear disciplinary orientation	no clear disciplinary orientation
Criteria for science	Elaborate, substantial criteria, strong focus on scientific method and results	broadest set of criteria, mostly focusing on scientific method and results, but also on trigger words and labels	fewer and less elaborate criteria, stronger focus on trigger words and labels	using mostly trigger words and labels, partly intuitive criteria
Patterns of Science-Related Information and Media -Use				
Sources and Content	print and online media most important, but overall very broad source repertoire; active, interest-driven use; abstract, elaborated coverage; STEM-& medicine oriented	print and online media most important, but overall broad source repertoire; active, but not scientifically oriented use; STEM-& medicine oriented	print and online media most important; moderately broad source repertoire; habitualized use; different kinds of coverage on different topics (including social science & humanities)	print and online media most important, but overall narrow media repertoire; no active search for science-related content; tabloids and soft news important; coincidental contact with science; different topics
Expectations and motivations	elaborated expectations: robust facts and knowledge, hard news must not immediately be relevant, but should be macrosocially relevant (now or in the future)	elaborated expectations: robust facts and knowledge, hard news societal or everyday relevance; should be relevant for their non-scientific job/ collecting of knowledge (for use in the future)	few expectations surprising, funny, extraordinary everyday relevance/ importance for one's own life/solution paths without imperative immediacy	almost no expectations; if at all: entertainment and everyday relevance entertaining: fun, surprise and irritation; optics immediate reference to one's own life (advisor)
Evaluation and credibility assessment of sources and content	strongly positive evaluation (79.6% positive entries/tags, 8.0% negative, 12.4% controversial, n=137); credibility assessments based on prior knowledge	positive evaluation (63.7% positive, 9.9% negative, 26.4% controversial, n=91); many different, elaborated criteria for credibility assessment	positive evaluation (67.2% positive, 7.6% negative, 25.2% controversial, n=119); credibility assessments not well defined, Gossip is classified as untrustworthy	still positive evaluation (61.5% positive, 3.8% negative), but largest amount of controversial evaluations (34.6%, n=26); credibility of content stems mostly from source, journalistic media seen as largely credible
Social Context of Use	use of science-related content mostly in private setting (75.5%, professional setting 10.9%, mobile 13.5%, n=229); not many, but most (but still not much) follow-up conversations and highest interest in them	use of science-related content mostly in private setting (77.9%, professional setting 10.7%, mobile 11.5%, n=131); a few follow-up conversations and interested in them	use of science-related content mostly in private setting (75.4%), but more often also in professional setting (14.7%, mobile 9.9%, n=191); not very interested in follow-up conversations and not having many	use of science-related content mostly in private setting (73.8%), but more often also in professional setting (14.3%, mobile 11.9%, n=42); not interested in follow-up conversations, not having many

Table 2: Overview of Core Findings.

4.2 Respondents’ Patterns of Science-Related Media and Information Use (RQ2)

The second aim of our study is to reconstruct respondents’ patterns of science-related media and information use. We analyzed sources and content participants used, their expectations towards and evaluations of these, and the social and situational embedding of the use of science-related content.

4.2.1 Sources and Content of Use

Respondents were asked to capture all encounters with science – from legacy media over museums and professional encounters to conversations with friends. Given this broad spectrum, it is surprising that the analysis of the mentioned channels within the entries reveal the main sources of science-related information to be similar in all four groups: print media followed by online sources, TV and radio. Sources such as social media, but also visits to museums or science centers play a negligible role. Of course, the latter are not part of a daily routine. Another parallel between all groups was that domestic media are most important, with foreign sources having little to no significance. Additionally, in all segments, around one third of the collected content was read, viewed of listened to only partly. Beyond these similarities, an analysis of the specific sources and the frequency of their use unearths differences between the segments.

Sciencephiles have a high interest in science and search actively for science-related content. They use a wide and diverse set of offline and online sources including special-interest magazines and science shows to find this content, use certain media daily and read the content they consume in detail and attentively. This content is usually related to STEM disciplines or medical research, and it is comparatively complex and challenging: The texts they read in print media, for example, are often long and abstract, dealing with topics that go beyond everyday life, such as brain research or the solar system. An interviewee explains that he read a text about astronomy because "[i]t's an exciting topic, but not important. I don't need it tomorrow at the meeting”. *Sciencephiles* are interested in the development of science and in its role in the future of mankind: “Science doesn't have to be useful immediately, but in the end something useful has to come out of it”.

Critically Interested have a relatively high interest in science. They consume a wide variety of sources, use certain media regularly and look for science-related content, which they mostly consume attentively. Like *Sciencephiles*, they focus on STEM and medical subjects, but rarely on social sciences and humanities. The content they consume also tends to be relatively extensive and complex, but less so than for the *Sciencephiles*. Additionally, the *Critically*

Interested value applicability more. Apart from acquiring knowledge about science in general, they are interested in information that is potentially relevant for their professional or personal lives, which they collect and go back to it when it becomes relevant. "Maybe that's a little selfish", said one interviewee, "I'm basically interested in things that bring me personal gain or concern my work". Another posited, "as a teacher, I am often confronted with students drinking energy drinks. It is always good when you have facts [like what effects these drinks have] and can inform and perhaps influence the children".

In contrast to these two groups, *Passive Supporters* have lower interest in science and a smaller set of science-related sources that mostly consists of news media. They habitually browse newspapers or watch TV news, and stick with topics they find interesting. This interest is not tied to specific topics – they display the widest variety of themes in their diaries – but rather to characteristics of presentation, entertainment value and utility. Catchy title and astonishing facts seem to attract *Passive Supporters*: "At first I found the topic exciting, especially the title", for example: "Look into my eyes", "Rock star of science" or "muscles from the spray can". Entertaining presentations, like Sitcoms a la "Big Bang Theory", appeal to them, as do topics that are of everyday utility such as dealing with stress or the health effects of drinking coffee, through which interviewees "wanted to acquire a certain know-how". Additionally, a focus on people intrigues *Passive Supporters*: Many of them found journalistic profiles of researchers interesting, a feature that was absent in the other segments. Their interest in science, albeit only moderately high, is broad and not focused on specific disciplines. Their encounters with science are often coincidental, and much of the science-related content that finds their attention is not consumed in detail, attentively or until the end.

The *Disengaged* are not particularly interested in science, and do not look for it in their lives. They mostly use tabloid newspapers and popular magazines in which science is only rarely touched upon, but they seem to have no routines of consumption. Therefore, encounters with science-related content are usually coincidental – e.g. when interviewees "check [their] mails and then check the Bluewin page [web portal with a focus on soft news] to see what's going on. If I like something, I visit the page." The content that catches the *Disengaged*'s attention is usually entertaining, funny or surprising (i.e. contradicting common knowledge) or has a strong and direct connection to everyday life – like male influenza, fasting or the toxicity of milk. For examples, see figure 2.

Figure 2: Typical media articles used by the different segments: a) *Sciencephiles*: article about how to destroy dormant cancers cells in tumors from www.chemiextra.com 3/2018; b) *Critically Interested*: article about an experiment testing the influence of climate change on the forest. Respondent keeps article to use it later in his teaching class, from Zofinger Tagblatt 14/3/2018; c) *Passive Supporters*: online article about how overweight influences health, a subject of direct relevance for daily live, from www.bluewin.ch 16/03/2018; d) *Disengaged*: a column (right side) called "useless knowledge" informing that exercise before breakfast boosts fat burning, from Migros-Magazin 11, 12/3/2018.

4.2.2 Expectations towards and Evaluation of Science-Related Content

We also asked respondents about their quality expectations of science-related content. Most of the *Disengaged* had no specific expectations. When they encounter science-related content, they expect advice they can implement directly into their own daily life. At the same time, content should be simple and entertaining: " [The "Useless Knowledge" column seen in Fig. 2] is actually useless, but funny. I just think it is nice when science goes in a direction; if it's too academic for me, then I don't read it".

Similar to the *Disengaged*, *Passive Supporters* have few specific expectations. Mostly, they look for explanations for everyday phenomena and like science-related content that has an immediate connection to their lives – it should "be relevant to me, my family, or society".

The demands of *Critically Interested* and *Sciencephiles* are considerably higher and more differentiated. First, they expect science-related content to present robust, proven and correct data: Presented facts "should be right, maybe have a statement". Second, and relatedly, *Sciencephiles* expect substance and seriousness. They do not just want to see results, but also background about the study, and an «article [that] goes deeper than most articles». Third, both *Sciencephiles* and *Critically Interested* expect that content should be of societal relevance more generally. This is particularly pronounced among *Sciencephiles*, while *Critically Interested* also value explanations for everyday phenomena ("I always care about the relation to reality"). Third, both groups think science-related content, ideally, should enable follow-up communication. It should provide the audience with knowledge that allows for well-grounded discussions both among friends and family and in professional contexts.

Additionally, we asked respondents how they *evaluated the science-related content* they encountered[3] and how they judge its *credibility*. Their replies showed that even though sources and content differed significantly, their evaluations across segments were very positive. The *Sciencephiles* exhibit the most positive evaluations, far ahead of the other segments. Similarly, the credibility of content was judged as generally high in all groups. However, the criteria that are used in the different segments to make these judgments differ:

The *Disengaged* mainly rely on source characteristics when making credibility assessments. As they consider most legacy media to be generally credible – "They most probably know what they're talking about» -, content from these media is found credible by extension. In doing so, the *Disengaged* do not seem to distinguish much between media types; tabloid newspapers enjoy the same credibility as quality broadsheets. The source is also the main credibility cue for most *Passive Supporters.* But in contrast to the *Disengaged,* they distinguish between media types: Advertising, social media or tabloids are considered less credible than public service television or quality newspapers. A few also mentioned that the mention of a professor or a university guarantees credibility. The evaluation of credibility rarely goes deeper. Vague criteria such as "the text is understandable" or "it is not gossip" are apart from the source most likely to be mentioned. Additionally, obscure criteria for credibility like "subjects which are of

[3] During the diary phase participants could choose between 21 tags such as 'understandable', 'academic', 'complex', 'superficial', 'banal','well-founded' or 'boring' to indicate what they thought about content. They also could create own tags. We grouped these terms into positive, negative and neutral.

less interest are more serious, because nobody tries to manipulate" or "If a picture of this spacecraft is published here and the text doesn't contradict it, I think it's quite credible".

Critically Interested have the most elaborate and differentiated criteria for credibility judgments. Every respondent had his own set correlating with his/her criteria for good science communication. For example: "The article was written by a professor at some institute. I had the feeling that he certainly wouldn't just chatter out into the world". Overall, their credibility judgments not only based on the channel, but also on the facts that researchers were cited, the researchers' individual or their university's reputation, by the depth of the explanation (including the number of details in tables and graphs), the logical deduction of resultsin the respective content, and the existence of references to scholarly literature. In contrast, the *Sciencephiles* employ only few credibility criteria, which correspond closely to scientific criteria: They rely on their previous knowledge of science, its actors and processes to decide about the credibility of science-related content.

4.2.3 The social context of use

We also assessed the situational and social contexts of use. Mostly, science communication was read, seen or heard in private and family setting. Of all the segments, *Passive Supporters* are most likely to have consumed science communication not only at home, but also at work or in the educational institution.

Participants were also asked if their consumption of science-related content had triggered *follow-up communication in their social circles*. Somewhat surprisingly, such conversations seemed to be rare in all segments. But there are differences between the segments, both in the amount of follow-up conversations and in their willingness and openness towards them: *Sciencephiles* and *Critically Interested* have not many, but still the most follow-up conversations compared to other segments, and they are also most interested in them: «Sometimes I read articles that are interesting, but also want to know what the other side says about it. Or talk to someone about it." (*Critically Interested*). Typically, if they discuss science-related content, they do so with family members who are close by. However, *Sciencephiles* in particular, with their high degree of knowledge and interest, also indicate that can be difficult for them to find suitable conversation partners.

5. Discussion

This study aimed to reconstruct people'S subjective perceptions and qualitative patterns of science-related information and media use. Smartphone-based media use diaries and semi-structured interviews were used to analyze 41 participants across four science communication audience segments.

Overall, the segments *Sciencephiles* and *Critically Interested* showed an elaborate understanding of science with a concentration on STEM and medicine subjects. They assess articles based on methodical design, presentation of results, researchers and previous knowledge. *Sciencephiles* look for science-related knowledge in different media, whereas *Critically Interested* use their set of media and scan it for science. The former are intrinsically interested in science and see its societal relevance. The latter want to collect knowledge, which may be used later in their profession. *Passive Supporters* and *Disengaged* do not have elaborate criteria for identifying and evaluating science (communication). Encounters occur randomly, but more frequently for *Passive Supporters* as they use news media more regularly. They are attracted by surprising, entertaining and visually striking articles or broadcast pieces, especially if the information is relevant for their daily live.

Overall, the results show that labelling is important for all groups, but especially for *Passive Supporters* and *Disengaged* to understand which information is related to science. This corresponds to the findings of earlier qualitative studies discussed at the beginning that people are often unaware of science in their everyday life. Moreover, the results underline to importance of high-quality science scientific journalism, as news media remain the main source of science-related information for all groups. Furthermore, the majority of all groups have a positive and uncritical attitude towards scientific research and science-related reporting. Given that non-mass media players account for a significant proportion of the information sources for all groups (about a quarter to a half), journalistic channels with transparent intention and quality standards are required. Also relatively often, participants encounter science-related content via online channels (see also NSF, 2018; Eurobarometer, 2005; Schäfer et al., 2018; Wissenschaft Im Dialog, 2015), but seldomly via social media or directly from research institutions. The reasons for the pronounced dominance of print sources can only be speculated upon. Perhaps science communication in social media does not penetrate the bubble of users and in newsfeeds they do not scroll down to the lower part where science is often placed. Print media may offer more opportunities for browsing and unexpected encounters. Although lack of time or distraction cannot be ruled out as reasons for the only partial reception of contributions, it also can be assumed that a lack of attractiveness of the contributions - i.e. a lack of individual addressing – plays a role.

Science-related content is usually consumed in private and family settings, where it can be viewed in-depth and where follow-up communication with family members is more likely.. But the fact that encounters with science-related content rarely seem to trigger follow-up communication across all segments is cause for concern, and may mean that citizens rarely actively participate in the broader public discourse on scientific topics. Here, the provider of science communication may have to do better: Not only should science communication reach its audience, be understood, assess science critically, provide knowledge and inspire trust in order to contribute to knowledge society – it also has to address different groups of citizens differently.

Beyond the research questions of this study, it is also worth reflecting whether the application of qualitative methods indeed adds value to the quantitative identification of audience segments and if the results support the segments. The diaries in combination with follow-up interviews gave detailed insight into the prevalence, use and evaluation of science and science-related content in peoples' lives.

Overall, the results are in line with the segment reconstructed by the "Science Barometer Switzerland" (Schäfer et al., 2018). Within segments, we found relatively homogenous diary and response patterns with just one or two outliers. But the qualitative comparison also shows that for some criteria, the boundaries between *Sciencephiles* and *Critically Interested* (amongst others evaluation criteria, definition of science) for *Critically Interested* and *Passive Supporters* (amongst others the average daily encounters with science), as well as between *Passive Supporters* and *Disengaged* (amongst others evaluation of science communication, reasons for use) blur.

Even though this study aimed to remedy the typical limitations of quantitative survey research by combining it with qualitative methods, it still has limitations. Keeping media diary is tedious, even though we minimized that by using smartphones, and may have led to respondents reporting fewer encounters with science than they actually had. Moreover, there may be a selection bias among participants, with people with a closer proximity to science being more willing to participate in our study. Moreover, the existence and characteristics of follow-up communication would have better been research after more time had passed between the diary and the qualitative interview. Nevertheless, the method allowed for the reconstruction of of fine-grained differences that had remained hidden in the previous quantitative segmentation analysis.

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